



Advanced Multifunctional Coating

presented at

2011 Air Force Corrosion Conference

by

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Overview

- **97GY156 Development**
- **97GY160 Development & Test Results**
- **C-17 Field Visits**
- **AMC Field Evaluation**
- **Next Steps**



97GY156 Development

C-17 POLLUTION PREVENTION

Boeing in 2004-2008 participated in the development of an improved self-priming topcoat (SPTC) with Deft Coatings

- Program goals were to improve adhesion, corrosion resistance and UV durability of then current chrome free TT-P-2756 SPTC
- Leverage APC technology into SPTC
 - Coating uses same fluoropolyurethane technology as APC currently used on C-17
- Leverage recent advances in chrome free corrosion inhibitor technology
 - State of the art chrome free corrosion inhibitor eliminates need for a primer



Development of AMC for C-17

C-17 POLLUTION PREVENTION

- Final product developed was 97GY156
- Coating good candidate for C-17 touch-up
- Leveraging 97GY156 technology, Deft reformulated to C-17 color standard; named product 97GY160, Advanced Multifunctional Coating (AMC)
- No major changes between the two coatings
 - Changes in color pigments only

Touch-up Process

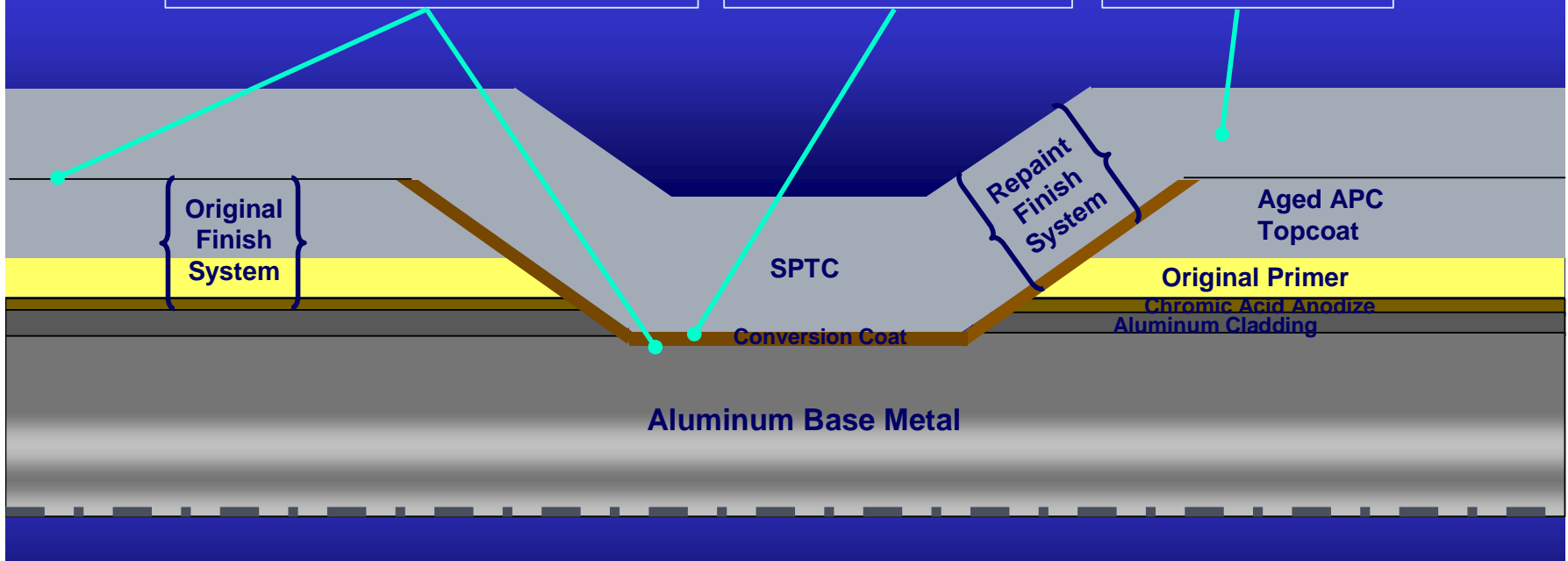
C-17 POLLUTION PREVENTION

SPTC Application Using TO Optimal Refinish Process

1. Bring entire aged surface to water-break-free condition with abrasive & clean water

2. Deox & conversion coat exposed metal

3. Apply SPTC topcoat to refinish area



97GY160 Test Results

C-17 POLLUTION PREVENTION

Three laboratory batches of 97GY160 tested

- Batch 1 – DoM* Jan 2007
 - Corrosion screening tests only
- Batch 2 – DoM* Feb 2008
 - Key qualification tests
- Batch 3 – DoM* Mar 2009
 - Selected tests. This batch, color matched to current APC topcoat, was evaluated to gain more data on rain erosion performance, color change on weathering, & viscosity.
- Matched or exceeded current system/requirements on all tests except color change in accelerated weathering

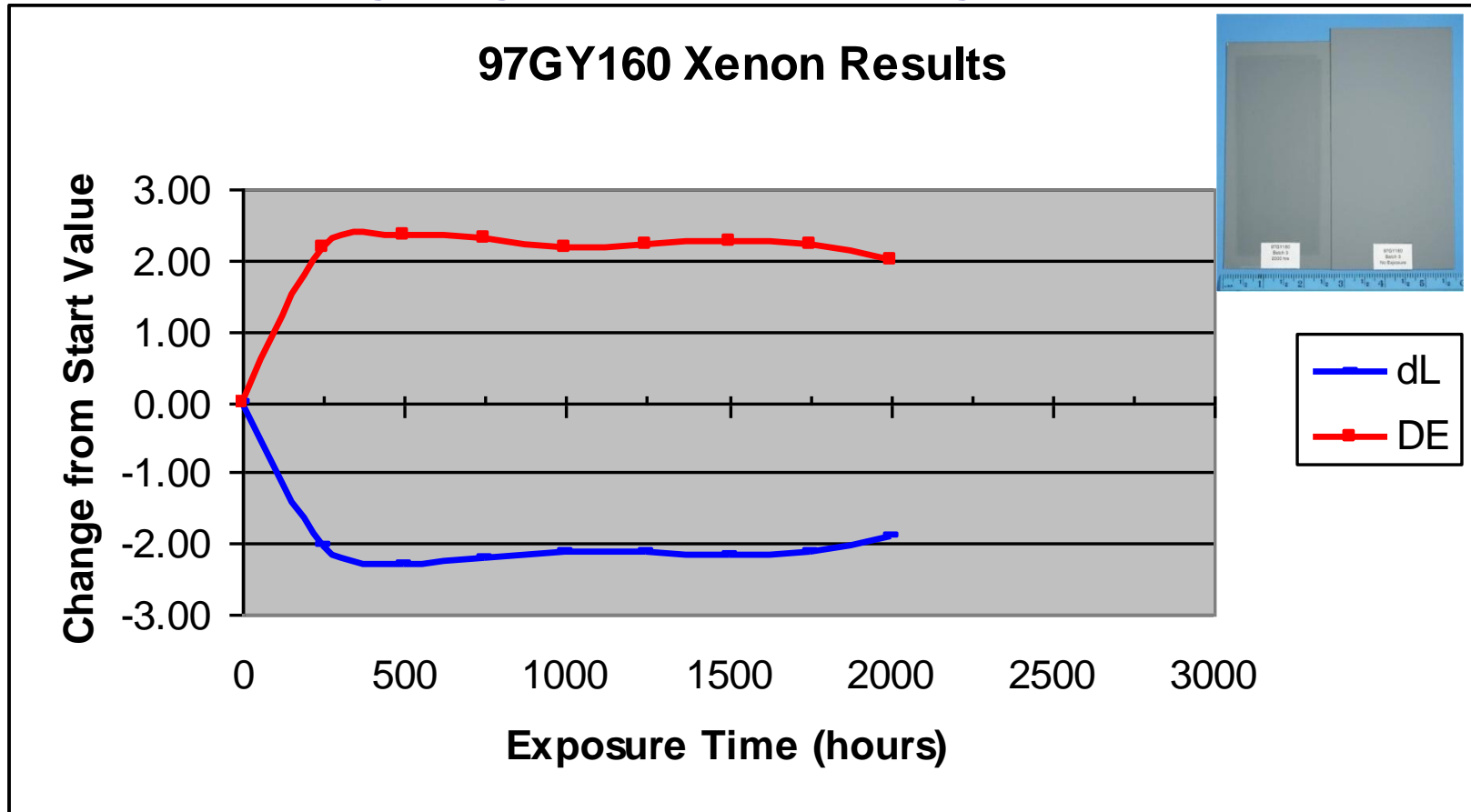
* DoM signifies date of manufacture

97GY160 Test Results

C-17 POLLUTION PREVENTION

Weather-O-meter® Exposure of 97GY160 Lab Batch #3

Graph shows curves for both delta E (total color change) & delta L (change in lightness / darkness). (Negative delta L = darker.)



97GY160 Test Results

C-17 POLLUTION PREVENTION

**2000-Hour Salt Spray – 2024 T-3 Bare, Alodine 1200
97GY160 Lab Batch # 2 vs. Current Coating System**

Chromate Primer + APC Topcoat



97GY160 AMC



97GY160 Test Results

C-17 POLLUTION PREVENTION

**2000-Hour Filiform – 2024 T-3 Clad, Alodine 1200
97GY160 Lab Batch # 2 vs. Current Coating System**

Chromate Primer + APC Topcoat



97GY160 AMC



97GY160 Test Results

C-17 POLLUTION PREVENTION

**2000-Hour Filiform – 7075 T-6 Clad, Alodine 1200
97GY160 Lab Batch # 2 vs. Current Coating System**

Chromate Primer + APC Topcoat



97GY160 AMC

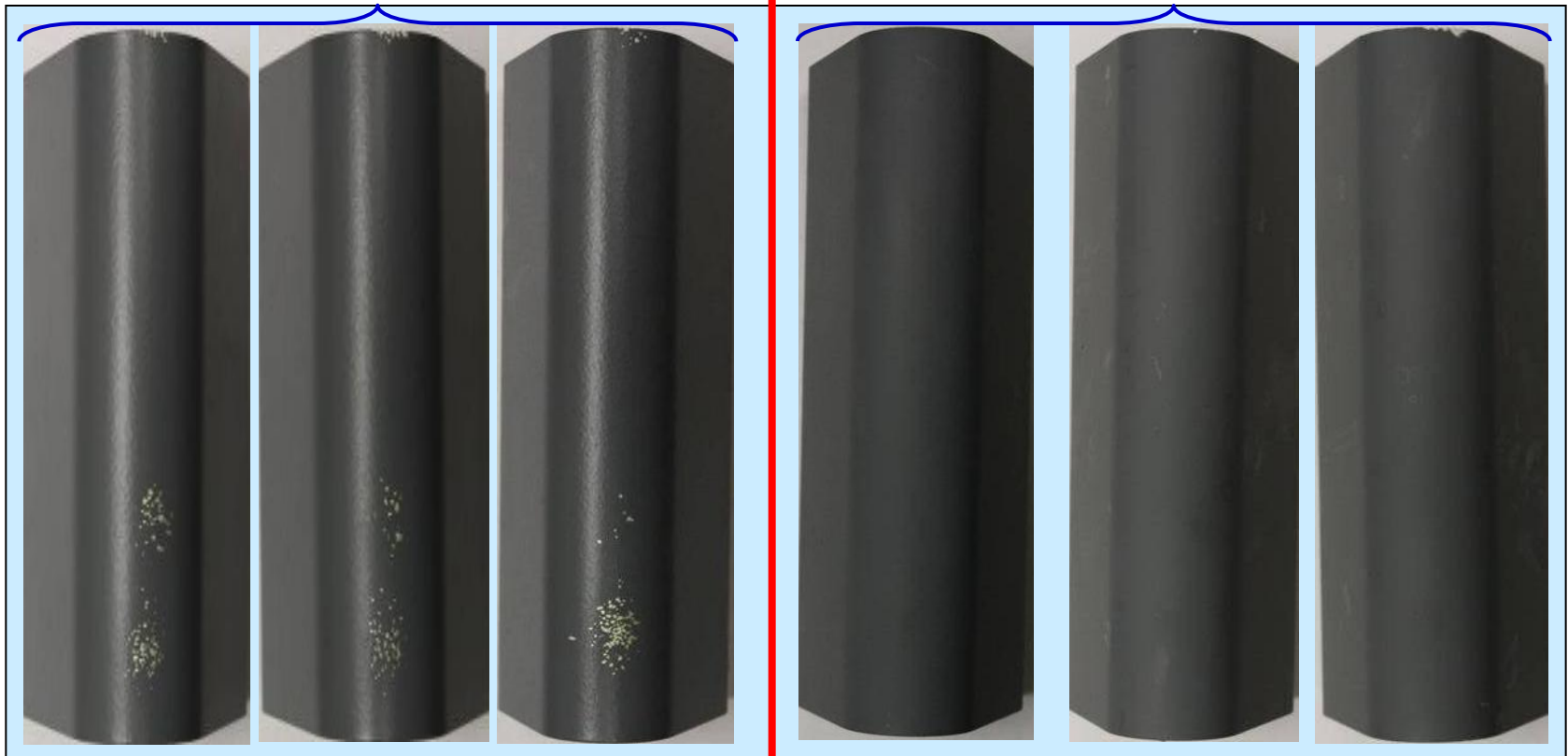


Rain Erosion Testing

C-17 POLLUTION PREVENTION

Spray OEM system - after 45 minutes

Spray AMC – after 120 minutes



3.1 mil average total DFT* for 3 foils

3.8 mil average DFT for 3 foils

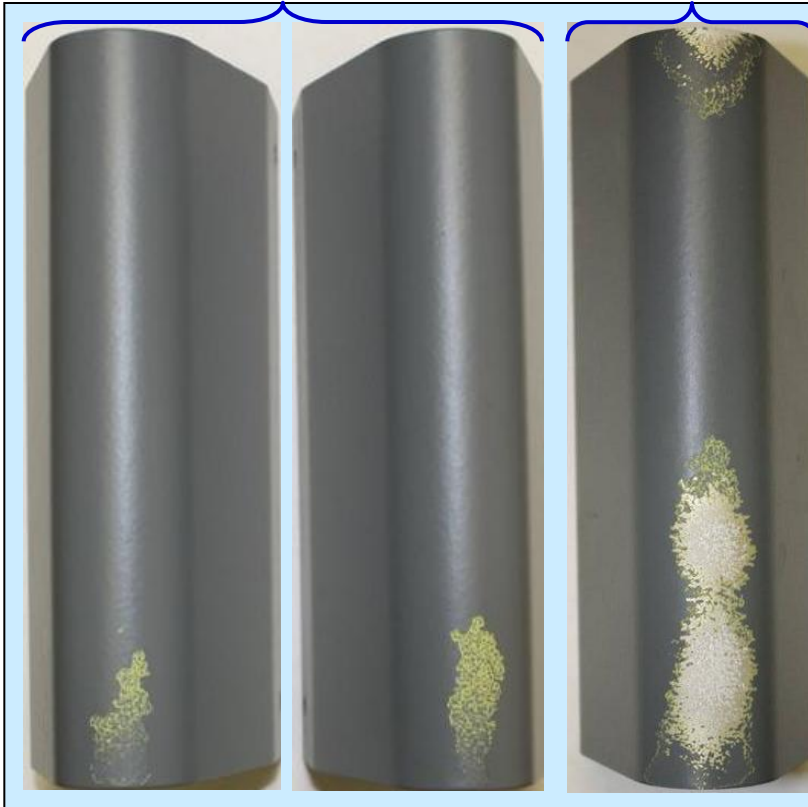
**DFT signifies dry film thickness*

Rain erosion evaluated due to issues associated with OEM system

Rain Erosion Testing

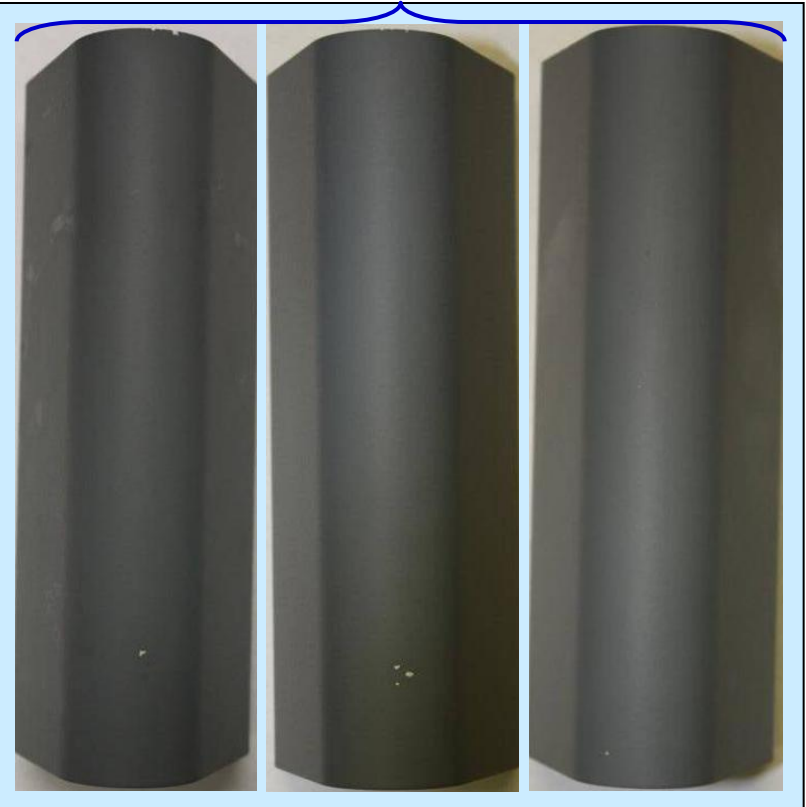
C-17 POLLUTION PREVENTION

Repaint OEM syst. over aged OEM syst.
after 30 min after 120 min



6.7 mil total average DFT for 3 foils

Repaint AMC over aged OEM syst. after
120 min

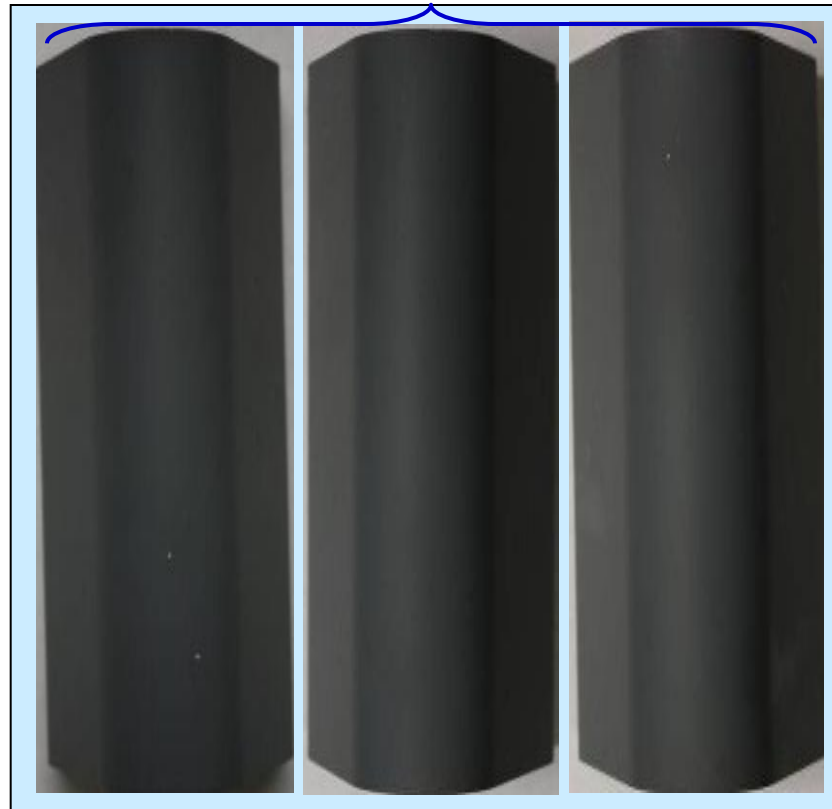


4.7 mil average DFT for 3 foils

Rain Erosion Testing

C-17 POLLUTION PREVENTION

Repaint ~ 2 mil AMC over ~ 2 mil aged AMC after 120 min





AMC Potential Benefits

C-17 POLLUTION PREVENTION

- **Environmental & Safety**
 - Reduced worker exposure to chrome, (97GY160 is chrome-free)
 - Reduced hazardous waste
 - No need for primer; therefore VOCs of primer are eliminated
 - Lower VOCs than C-17 advanced performance coating (APC)
- **Appearance & Durability**
 - Deft 97GY160 has demonstrated better rain erosion resistance vs. current primer / topcoat in whirling arm testing
- **Experience with Similar Coating**
 - Fluoropolyurethane resin base same as in current APC used on C-17 exterior; same supplier
- **Labor & Flow Time Reduction**
 - No primer application & equipment cleaning, no primer dry time
 - Reduced masking
- **Weight Saving**
 - Aircraft accrues less weight due to elimination of primer
- **Multiple benefits even if rain erosion is not improved**



Field Visits

C-17 POLLUTION PREVENTION

- Purpose of field visits was to gather data on C-17 leading edge paint failures and flight hours
- Inspected P-180 through P-189
 - Correlate flight hours to amount of leading edge damage
 - Investigate failure mechanism
 - Eventually predict how AMC would improve rain erosion resistance of C-17 leading edges based on inspections and whirling arm test results

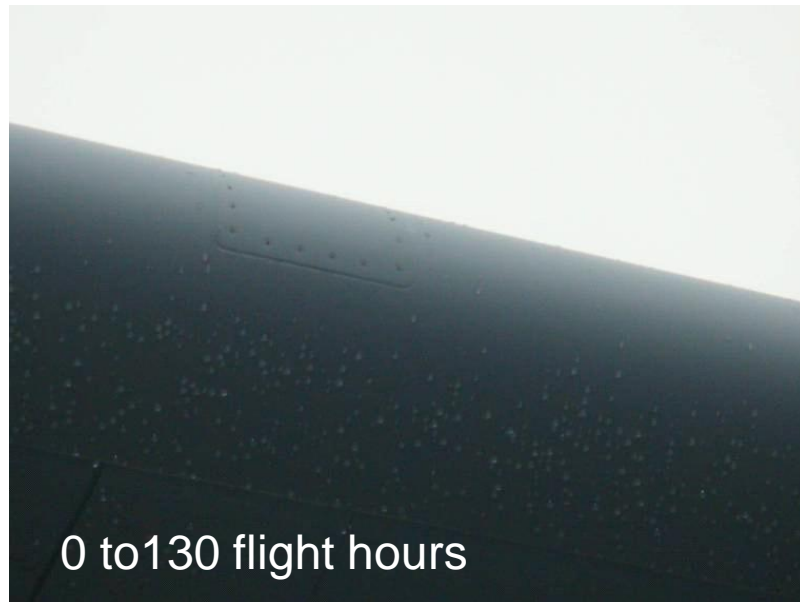
Field Visits

C-17 POLLUTION PREVENTION

| Aircraft | Paint Job | Flight hours since last paint | Leading edge condition |
|----------|------------------|-------------------------------|--|
| P-190 | OEM | 130 | No rain erosion or rivet rash |
| P-41 | strip & repaint | 217 | No rain erosion, early isolated rivet rash and adhesion loss around access panels |
| P-45 | strip & repaint | 291 | Moderate rain erosion left and right slat 4 and rivet rash all slats |
| P-188 | OEM | 320 | Rivet rash all slats |
| P-190 | OEM | 730 | Isolated slight rain erosion, start of rivet rash |
| P-187 | OEM | 603 | Rivet rash all slats |
| P-184 | OEM | 880 | Isolated slight rain erosion, start of rivet rash |
| P-189 | OEM | 897 | Rivet rash all slats |
| P-185 | OEM | 991 | Rivet rash all slats |
| P-98 | scuff & overcoat | 1057 | Moderate rain erosion and isolated rivet rash. Leading edge failure to bare metal |
| P-188 | OEM | 1083 | Rivet rash all slats. Some continuous vertical erosion along fastener rows/start of erosion |
| P-183 | OEM | 1250 | Isolated moderate rain erosion, rivet rash all slats |
| P-182 | OEM | 1324 | Isolated moderate rain erosion, rivet rash all slats |
| P-180 | OEM | 1521 | Isolated moderate rain erosion, rivet rash all slats |
| P-181 | OEM | 1634 | Isolated moderate rain erosion, rivet rash all slats |
| P-38 | strip & repaint | 1827 | Moderate rain erosion and isolated rivet rash all slats |
| P-36 | strip & repaint | 2252 | Severe rain erosion left hand slats 3 & 4 |

Leading edge erosion progression

C-17 POLLUTION PREVENTION





Field Visit Summary

C-17 POLLUTION PREVENTION

- Earliest leading edge failure around rivets after 217 flight hours (strip & repaint)
- Earliest failure across leading edge after 291 flight hours (strip & repaint)
- Based on this data it appears that leading edge erosion is slightly worse with strip and repaint than OEM paint with comparable flight hours
- Initial failure is not typical rivet rash
 - Failure moves out from around fastener
 - Fasteners still have paint on them
 - Non-continuous or thin paint around fastener/hole and seams fails from rain/sand erosion



AMC Field Evaluation

C-17 POLLUTION PREVENTION

- C-17 Division approved AMC field evaluation for McChord, Elmendorf and Hickam AFB's
 - Two aircraft – one wing leading edge slats
 - Six aircraft – all areas requiring repaint
 - 4 mils target thickness for AMC leading edges
 - 2 mils target thickness for AMC all other areas
 - One additional aircraft targeted for Elmendorf AFB



AMC Production Batch Manufacture

C-17 POLLUTION PREVENTION

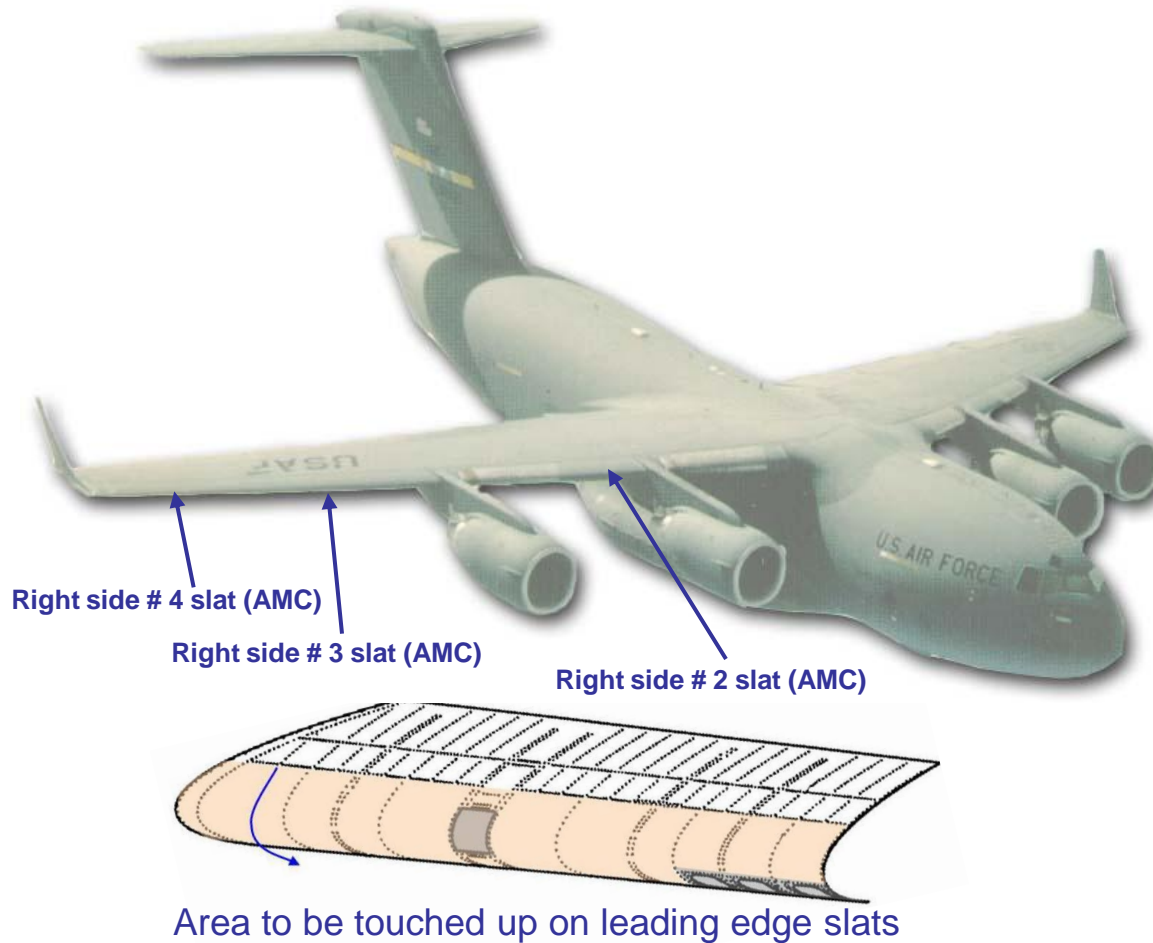
- Two production batches of AMC manufactured
 - 50 gallon production batch manufactured on 3/23/2010
 - 20 gallon production batch on 3/15/2011
 - Test results similar to three lab batches



AMC Field Touch-Up Evaluation

C-17 POLLUTION PREVENTION

C-17 Wing Leading Edge Slats, Right side with AMC



First AMC Aircraft

- P-87 (tail no. 10187) right wing leading edge slats painted with AMC on April 28, 2010 at McChord AFB
 - Ranie Feiock, Corrosion Control Program Manager and TSgt Anthony Nowak, Assistant Corrosion Control Program Manager were main POC's
 - P-87 aircraft was identified as CAT III ranking, indicating a paint condition that may include sectionalized painting of wing leading edges, nacelles and flaps
 - P-87 had a scuff and overcoat on November 2007

P-87 After Sanding



Test wing right side slats 2, 3 and 4 after sanding with 120 and 220 grit sand paper

P-87 Alodine Process

- Process per Henkel Surface Technologies Process Bulletin No. 234113
 - Deoxidine 605 scrub for 1-3 minutes
 - Water rinse
 - Alodine 1201 for 1-5 minutes
 - Water rinse
 - Dry



Alodine kit



Deoxidine scrub

P-87 Alodine Process

C-17 POLLUTION PREVENTION



Test slats after alodine process

P-87 Paint Process

C-17 POLLUTION PREVENTION



Test slat after masking



TSgt Nowak applying AMC

P-87 Process

C-17 POLLUTION PREVENTION



Good color match of AMC with wing



AMC next to soot covered wing

Other Areas Requiring Paint on P-87



Note: Front main landing gear door to be protected from liquid oxygen system via Charleston AFB suggestion

P-87 Inspections

- **AFTO-95 document (aircraft historical record) updated to include that the leading edges are inspected at approximately every 500 flight hours**
- **500 hour inspection was also entered into the aircraft plans & scheduling system**

Other Test Aircraft

C-17 POLLUTION PREVENTION

- P-86 (tail no. 10186) painted with AMC on May 25, 2010 at McChord AFB
 - Identical process as that used on P-87
- P-17, (tail no. 930601) painted on July 25, 2010 & P-10, (tail no. 00535) painted September 27, 2010 had all areas painted with AMC at McChord AFB
- P-68, (tail no. 990168) painted November 15, 2010 & P-67, (tail no. 990167) painted March 3, 2011 had all areas painted with AMC at Elmendorf AFB
- P-151, (tail no. 55151) had all areas painted with AMC at Hickam AFB on March 24, 2011 and P-152 (tail no. 55152) had nose painted with AMC on July 15, 2011



P-87 after 1064 Flight Hours

No discrepancies either wing

C-17 POLLUTION PREVENTION

Left Primer/APC wing



Right AMC wing



Left Primer/APC wing



Right AMC wing



P-86 after 1306 Flight Hours

No discrepancies either wing

C-17 POLLUTION PREVENTION

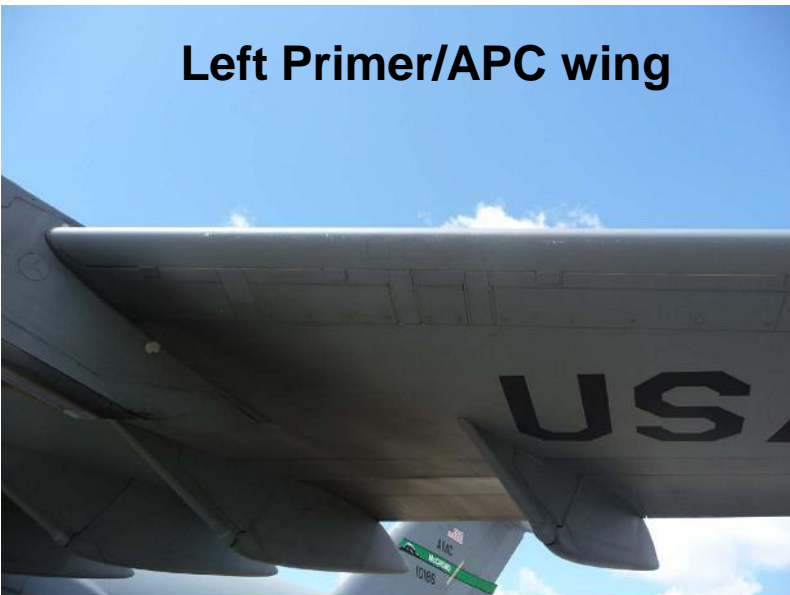
Left Primer/APC wing



Right AMC wing



Left Primer/APC wing



Right AMC wing





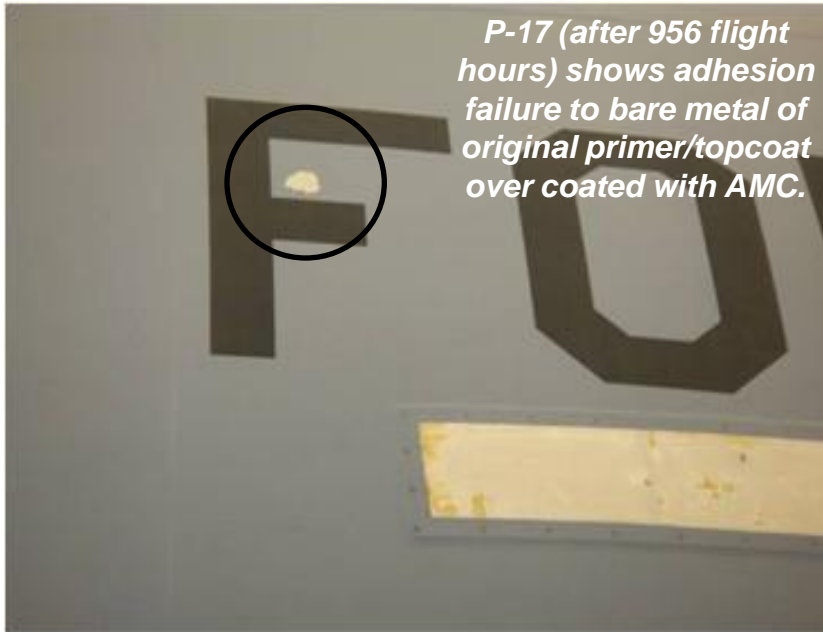
Field Inspection Summary

C-17 POLLUTION PREVENTION

- Eight fielded AMC aircraft
 - Over 5000 flight hours on fielded aircraft
 - Ten inspections
 - AMC performing very well !
 - One minor discrepancy identified
 - » P-17 after 956 flight hours

Discrepancy on P-17 after 956 Flight Hours

C-17 POLLUTION PREVENTION



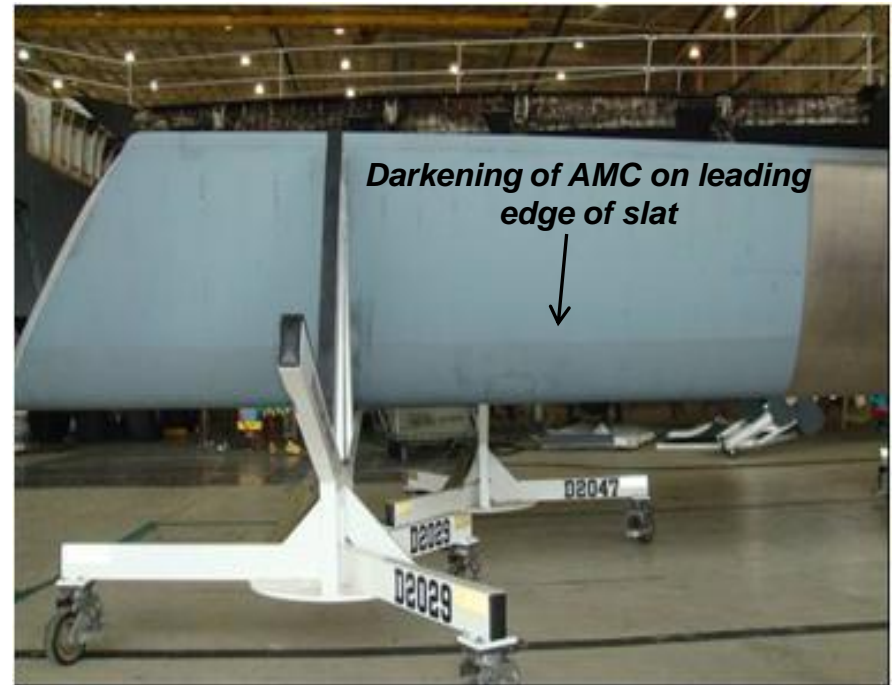
Discrepancy found during inspection at Warner Robins

Color match issues

C-17 POLLUTION PREVENTION



P113 recently touched-up with APC.



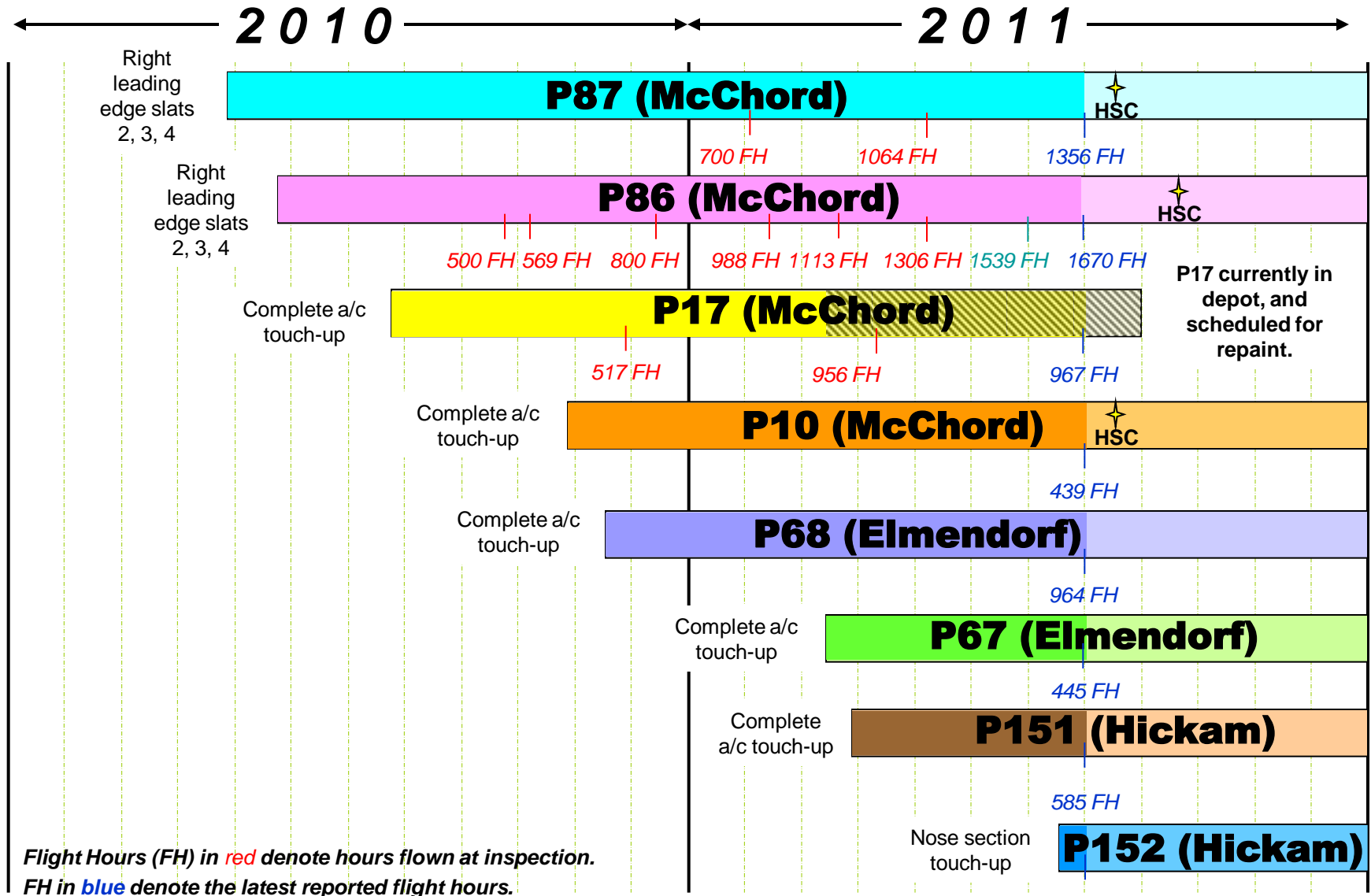
P17 slat after 956 flight hours after leading edge touch-up with AMC.

AMC color match visually no different than routine touch-up areas using APC



C-17's Currently Under Evaluation

C-17 POLLUTION PREVENTION





Future plans

C-17 POLLUTION PREVENTION

- Continue monitoring fielded aircraft
- Touch-up one additional C-17 with AMC
- Coordinate approval process for AMC incorporation into the -23 T.O.
- Evaluate chrome free pretreatments with AMC for a chrome free touch-up system
- Evaluate AMC as a candidate for scuff & overcoats and/or strip & repaints



Acknowledgments

C-17 POLLUTION PREVENTION

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Questions ?